

REMARKS

Claims 2 and 14 have been canceled; claims 1, 3, 5-8, 11, 13, 15, 17-20, 22 and 24 have been amended; claims 1, 3-13 and 15-25 are pending.

Numerous changes have been made to the specification to correct translational errors and for purposes of clarity only. No new matter is added thereby. All of the suggested changes have been made to the specification.

Turning to the rejections based upon the prior art, the Patent Office rejects claims 1-2, 7, 13-14, 19, 21-22 and 24 under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 6,387,806 ("Wang"). Applicant respectfully submits that this rejection is improper for the following reasons.

At the outset, under MPEP § 2131,

[t]o anticipate a claim, the reference must teach every element of the claim. A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference.

Citing, Verdegaal Bros. v. Union Oil Co. of California, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987).

Wang simply does not teach or suggest every claim element of independent claims 1 and 13. Specifically, independent claims 1 and 13 require the formation of a copper wiring that includes the CMP treatment of a copper layer to such an extent that the copper layer has a concave surface from a top view thereof and that the lower most portion of the concave surface dips below a top surface of the interlayer insulating layer. Then, this concave top surface of the copper layer is converted to a convex top surface using an anneal process. These two process steps are common to both independent claims 1 and 13. See Figs. 2B and 3B of the present application. Then, either a copper anti-diffusion insulating film or a copper anti-diffusion conductive film is formed on top of the convex surface.

Wang does not teach or suggest this process. The Patent Office relies upon Fig. 14 of Wang because it illustrates a recess 228 that is achieved by a "polished down" process. See Wang at column 9, line 16. However, Wang then fills that recess with a copper alloy 232 as shown in Fig. 15. At no time does Wang teach or suggest an annealing process to convert the recess or concave surface 228 into a convex surface as shown in Figs. 2B or 3B of the present application. In fact, by filling in the recess 232 of the copper alloy, Wang fails

entirely to avoid the problem of electro-migration and stress migration at a junction of the copper wiring 244 and the encapsulating film 222 (see Fig. 19 of Wang) as explained in connection with Fig. 1 of the present application.

Therefore, because Wang does not teach or suggest every claim element of either independent claims 1 or 13, Wang cannot serve as an anticipating reference for any pending claim.

Next, the office action rejects claims 1 and 9-10 under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 6,251,786 ("Zhou").

However, Zhou fails to recite a combination of both a recessed copper wiring layer or a concave copper wiring layer which is then converted to a convex layer by annealing. Further, Zhou does not teach or suggest the formation of a copper layer with a concave surface that dips below an interlayer insulating layer. In Fig. 4, the copper material 26 only extends below the cap layer 18, which is not equivalent to an interlayer insulating layer as recited by independent claims 1 and 13. Thus, for this additional reason and further because Zhou fails to teach or suggest the concave copper structure achieved by extensive CMP processing followed by a convex copper structure achieved by annealing, Zhou cannot serve as an anticipating reference for independent claim 1.

Next, the office action rejects claims 1 and 9-10 under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 6,274,499 ("Gupta"). Applicant respectfully submits that this rejection is improper for the following reasons.

Like Wang and Zhou, Gupta fails to teach or suggest the formation of a concave top surface in a copper layer followed by an annealing step which converts the concave surface into a convex surface. While Fig. 9 does teach the formation of substantial removal of the copper layer by excess CMP, Gupta in no way teaches or suggests a subsequent annealing step which results in any form of a convex structure. Thus, like Wang and Zhou, Gupta fails to serve as an anticipating reference for claim 1 and the rejection of claims 1 and 9-10 is improper and should be withdrawn.

Next, the Patent Office rejects claim 13 under 35 U.S.C. § 102(b) as allegedly being anticipated by U.S. Patent No. 6,083,835 ("Shue"). Applicant respectfully submits that this rejection is improper for the following reasons.

Specifically, Shue in no way teaches or suggests the formation of a concave copper layer followed by an anneal step that results in a convex copper layer top surface. At

best, Shue only discloses concave structures and not the subsequent convex structure as required by independent claim 13.

Therefore, the anticipation rejection of amended independent claim 13 is improper and must be withdrawn.

Next, the office action rejects claim 13 under 35 U.S.C. § 102(b) as being anticipated by U.S. Publication No. 2001/0013617 ("Toyoda"). Applicant respectfully submits that this rejection is improper for the following reasons.

The Patent Office relies upon Figs. 3 and 4 of Toyoda. While Figs. 3 and 4 do disclose copper layers whose top surface appear to be lower than that of a corresponding insulating film top surface 32, the similarity between Toyoda and claim 13 ends there. Toyoda does not teach or suggest an annealing step that transforms any copper structure from a concave configuration to a convex configuration. Therefore, Toyoda does not teach or suggest at least two different process steps of independent claim 13. That is, at a minimum, Toyoda does not teach or suggest the annealing of a concave copper layer to form a convex structure and the deposition of an anti-diffusion film on top of a convex copper structure.

Therefore, applicant respectfully submits that the anticipation rejection of claim 13 based on Toyoda is improper and should be withdrawn.

Next, the office action rejects claims 13-15, 19, 21, 23 and 25 under 35 U.S.C. §102(e) as allegedly being anticipated by U.S. Publication No. 2003/0109129 ("Saito"). Applicant respectfully submits that this rejection is improper for the following reasons.

The Patent Office appears to be relying upon Fig. 5 of Saito. While Fig. 5 discloses a film M1c, M1b with a concave upper surface, the similarities between Saito and independent claim 13 end there. Saito in no way teaches or suggests an annealing of the structure with a concave copper surface to convert it to a copper structure with a convex surface. Further, Saito does not teach or suggest the deposition of any anti-diffusion film on a copper structure having a convex surface. Because Saito does not teach or suggest this convex surface, Saito provides no solution to the problem of electro-migration and stress migration illustrated in Fig. 1 of the present application and solved by the methods of independent claims 1 and 13.

Therefore, because Saito does not even come close to reciting all of the process steps of independent claim 13, applicant respectfully submits that the anticipation

rejections of claims 13, 15, 19, 21, 23 and 25 based on Saito are improper and should be withdrawn.

Next, the office action rejects claims 16-18, 20, 22 and 24 under 35 U.S.C. § 102 as being unpatentable over Saito. Applicant respectfully submits that this rejection is improper for the following reasons.

At the outset, under MPEP §§ 2142 and 2143,

[t]o establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure.

Citing, In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991); *see also* MPEP § 2143-§ 2143.03 for decisions pertinent to each of these criteria.

As established above, Saito does not teach or suggest all of the process steps of independent claim 13. Saito does not teach the formation of a concave copper structure followed by an annealing step which converts the concave copper structure to a convex copper structure and, the deposition of an anti-diffusion layer on the convex copper structure which provides a solution to the electro-migration and stress migration problems discussed in the background section of the present application. Because Saito fails entirely to teach or suggest all of the claim limitations and further because there is no teaching or suggestion in Saito that would lead one skilled in the art to make the necessary changes in Saito to arrive at all of the claim limitations of independent claim 13, Saito fails to establish a *prima facie* case of obviousness of independent claim 13 for at least two different reasons.

Therefore, applicant respectfully submits that all obviousness rejections based upon Saito fail to meet the criteria of §§ 2142 and 2143, are improper and must be withdrawn.

Finally, the office action rejects claims 3-6, 8-12, 15-18, 20, 23 and 25 under 35 U.S.C. § 103 as being unpatentable over Wang in combination with U.S. Publication No.

2003/0114000 ("Noguchi"). Applicant respectfully submits that this rejection is improper for the following reasons.

The deficiencies of Wang are set forth above. Wang does not teach or suggest the formation of a concave copper structure followed by an annealing step which converts the concave structure into a convex copper structure followed by the deposition of an anti-diffusion film on the convex copper structure. Noguchi is only cited for the proposition that it teaches cleaning processes, an annealing process and a plasma process. However, Noguchi is not cited for, nor does it teach the formation of a concave copper structure, the annealing of that concave structure to a convex structure and a deposition of an anti-diffusion film on the convex structure.

Noguchi does teach annealing which results in a slightly convex structure as shown in Fig. 10. However, Noguchi does not begin with a concave structure. Neither does Wang. The Wang concave structure shown in Fig. 14 is then filled in with copper oxide material 232. Thus, there is no heat treatment of Wang's concave structure 228. Wang, instead, teaches that the recess 228 should be filled with a second copper alloy 232. See Wang at column 9, lines 35-37. Then, Wang teaches a heat treatment that results in the formation of an encapsulating material 222. See column 9, lines 53-67.

Thus, Wang does not teach or suggest the formation of a concave structure and converting that concave structure to a convex structure. Wang instead fills any recess with additional alloy. Noguchi, on the other hand, begins with a planar structure (see Fig. 10) and anneals that structure from its planar configuration. Thus, Noguchi does not teach or suggest the heat treatment of any concave structure, but only the heat treatment of planar structures.

Noguchi, then teaches farther away from claim 13 by requiring an insulating layer 15b, which is not equivalent to the anti-diffusion conductive film recited in claim 13.

Therefore, there is no combination of Wang and Noguchi that teaches or suggests the formation of a concave copper structure, the annealing of that concave copper structure to convert it to a convex copper structure followed by the deposition of an anti-diffusion conductive film on the convex structure. Accordingly, no combination of Wang and Noguchi teaches or suggests all of the claim limitations of independent claims 1 and 13 and therefore applicant respectfully submits that no combination of these two references establishes a *prima facie* case of obviousness under §§ 2142 or 2143.

Therefore, applicant respectfully submits that the obviousness rejections based upon Wang and Noguchi are improper and should be withdrawn.

With all rejections having been addressed and traversed, applicant respectfully submits that this application is in a condition for allowance and an early action so indicating is respectfully requested.

The Commissioner is authorized to charge any fee deficiency required by this paper, or credit any overpayment, to Deposit Account No. 13-2855.

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Respectfully submitted,

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